1.1 Glossary of Terms and Acronyms

AADT – Annual Average Daily Traffic. The average daily volume of traffic estimated on a yearly basis based on one year (365 days) of data.

AADTF – Average Annual Daily Traffic Factor. The AADTF provides the day-of-week and monthly adjustment of coverage traffic volumes with respect to the AADT.

AASHTO – American Association of State Highway and Transportation Officials.

AAWDT – Annual Average Weekday Traffic. To compute this statistic, the MAWDT's for each month are summed and then divided by 12.

AAWET – Annual Average Weekend Traffic. To compute this statistic, the MAWET's for each month are summed and then divided by 12.

ADT – Average Daily Traffic. The total volume of traffic during a given time period (in whole days greater than one day and less than one year) divided by the number of days in that time period. ADT volumes can be determined by continuous traffic counts or periodic counts. Where only periodic traffic counts are taken, ADT volume can be established by applying correction factors such as for season or day of week. For roadways having traffic in two directions, the ADT includes traffic in both directions unless specified otherwise.

ATR – Automated Traffic Recorder

AWDT – Average Weekday Daily Traffic. The total traffic volume for an average weekday. AWDT is a representative weekday traffic volume computed as the mathematical average of typical weekday volumes selected throughout the year. A typical weekday has no anomaly such as heavy traffic due to a special public event or light traffic due to inclement weather.

AWET – Average Week End daily Traffic. The total traffic volume for an average Saturdays weekend day (Saturday or Sunday). AWET is a representative weekend traffic volume computed as the mathematical average of typical weekend days selected throughout the year. A typical weekend day has no anomaly such as heavy traffic due to a special public event or light traffic due to inclement weather.

DHV – Design Hour Volume, the DHV is the thirtieth highest hourly two-way traffic volume for the design year, commonly twenty years from the time of construction. The DHV is given in units of vehicles per hour.

FOTSC – Field Operations Technical Support Center

FHWA – Federal Highway Administration, the lead agency for this project.

FLH – Federal Lands Highway

GIS – Geographical Information System

GPS – Global Positioning System

K-Factor – A factor which represents the proportion of AADT expected to occur in the design hour. The K-factor is also known as the design hour factor and is normally expressed in design problems as DHV=AADT x K

LTPP – Long-Term Pavement Performance

MADWT – Monthly Average Day of the Week Traffic, averaged daily traffic volumes for each of the seven days of the week are for each month.

MAWDT – Monthly Average Weekday Traffic, the MADWT for Monday through Friday are summed and then divided by 5.

MAWET – Monthly Average Weekend Traffic, the MADWT for Saturday and Sunday are summed and then divided by 2.

MADT – Monthly Average Daily Traffic, the MADWT for Monday through Sunday are summed and then divided by 7.

NPS – National Park Service

PDS – Percentile Directional Split. The PDS is the percentage of the total, two-way peak hour traffic traveling in the peak direction. For continuously monitored sites, the peak hour traffic is determined as the 30th highest hour of the design year. For the short duration 48-hour coverage sites, the peak hour of the base 24-hour volume is used in the directional split computation.

Reference Station – an ATR reference station used to obtain seasonal and annual adjustment factors for coverage counts.

RIP – Road Inventory Program

SADT – Seasonal Average Daily Traffic. An average daily traffic volume computed for the season defined as those full months that contain 80 percent of the annual traffic

volume. A park may have more than one season; therefore, the months used in SADT computation may not be consecutive.

SADTF – Seasonal Average Daily Traffic Adjustment Factors, used to estimate the SADT based on the coverage counts. The SADTF provides the day-of-week and monthly adjustment of coverage traffic volumes with respect to the SADT volume.

TMG – Traffic Monitoring Guide

VMT – Vehicle miles traveled a unit of measure that is used to calculate the total miles traveled by vehicles in a specified area for a specific period of time.

1.2 Introduction

This report contains the results of the traffic data study conducted as a part of the National Park Service (NPS) Traffic Monitoring Program designed to provide system coverage traffic data. In addition to the results obtained during current traffic data collection effort, the report includes summary results and traffic statistics from the similar efforts done in 1988, 1991, and 1994. The reader should note that although the information presented in this report and in the traffic database has been thoroughly reviewed, the statistics used to develop the report, as all statistics, are subject to accuracy limits. Therefore, while this report is intended to provide a representation of actual situations, it is not presented, nor should it be interpreted, as absolute facts.

1.2.1 The NPS/FHWA Traffic Monitoring Program Overview

This report is part of an ongoing program managed jointly by the NPS and the Federal Highway Administration (FHWA) to monitor traffic on national park roads and provide information in support of traffic safety, transportation planning, visitor-use planning, roadway maintenance, bridge and pavement management, and traffic operations programs.

In 1984, the Branch of Transportation of the NPS Denver Service Center began installing a system of permanent traffic counting equipment. By 1989, equipment had been installed at all 59 park units planned for in the program. In subsequent years, a number of parks have been withdrawn from the program based on evaluations of their traffic data and the need to make more effective use of the staffing available to conduct the program. The parks remaining in the program today represent those with the highest traffic and include parks with notable traffic safety concerns.

The traffic data collection program at each park unit consists of four types:

1. Continuous volume counts at limited permanent locations.
2. Short-term volume counts covering a large number of locations.
3. Short-term manual vehicle classification counts at strategic locations.
4. Short-term manual vehicle occupancy counts at strategic locations.

1.2.2 Report Organization

This report represents a 2004 update of the 1994 report. This report consists of two sections and an appendix. Section 1 includes a discussion of the information in this report and the procedures and guidelines used in its generation. The subjects discussed are as follows:

- Glossary of Terms and Acronyms
- Introduction

- Data Collection
- Quality Control/Quality Assurance Procedures
- Data Analysis
- Data Retention
- VMT Summary by Park

Section 2 contains Park Traffic Packages for the individual parks. The organization, contents, and details on the individual sheets included in the Park Traffic Packages are described at the beginning of Section 2. The traffic database developed during the course of this study is provided on a CD as part of the Appendix A.

1.2.3 Traffic Database

Traffic data and accompanying traffic statistics are included in the Traffic Database CD. Traffic database file is called **Traffic_database.mdb.** Traffic database table description, structure, and individual data elements included in each table are discussed in details in the Appendix A.

1.3 Data Collection

1.3.1 Automatic Traffic Recorder Station Data

Each park included in the study contains at least one Automatic Traffic Recorder (ATR) that provides continuous counts on a roadway within the park. Continuous counts are taken up to 365 days a year. ATR data are collected for each lane equipped with a detector loop that is connected to an ATR unit. The counts are transmitted to the Field Operations Technical Support Center (FOTSC) of the NPS Washington office located in Denver, Colorado where they are processed to obtain monthly reports by hour and by lane. Each monthly report is then pre-screened to identify the obvious data anomalies and then saved to an ASCII file that is stored on a designated computer. Each ASCII file contains the hourly traffic volume information by lane for a given ATR station and a given month. For the years 2000-2004, these data were obtained and processed through a series of edit checks as recommended in the *AASHTO Guidelines for Traffic Data Programs* [1] and the *FHWA Traffic Monitoring Guide* [2]. For Colonial and Yosemite National Parks, 2005 data were also considered in the analysis. The data for the 12 most recent months were used to estimate the AADT and SADT for the roads covered by ATRs and to compute annual and seasonal adjustment factors needed to convert the short duration traffic volume counts into AADT, SADT, and VMT estimates.

1.3.2 Coverage Count Data

In addition to the permanent ATRs collecting data throughout the parks, coverage traffic volume counts were conducted in each park by data collection crews using pneumatic road tube and portable counters. The coverage counts consisted of

short-term 48-hour counts collected on homogenous traffic sections and distributed throughout the park road network to provide a representative coverage of the road system within each park unit. The *FHWA Traffic Monitoring Guide* [2] states a roadway "segment" is treated as homogenous traffic section if traffic volume is essentially the same for the entire segment. The homogenous traffic sections for the NPS road networks were defined as follows:

- For limited access highways (like parkways), segments were bounded by interchanges.

- For rural or local access roads, where access and egress along a several-mile segment is limited to a few driveways, segments were bound by major intersections.

Coverage Count Schedule

Whenever possible, the coverage counts were conducted during the park's high visitation season. The park visitation season was based on the full months that carry 80 percent of the annual traffic of that park. In addition, the traffic patterns within each park were analyzed to determine if the park has predominantly weekday or weekend traffic. This information was used to schedule the data collection of the coverage counts. Information about the dates when actual coverage counts were collected is provided in the *Traffic Volume Summary* sheets included in each *Park Traffic Report* package; Section 2 of the report.

After each coverage count was conducted, the data were quality checked before leaving the park to determine if any recounts were necessary. Quality checked data were delivered for processing and quality assurance. In the cases where 48-hour coverage count data did not pass the quality checks, the count was recollected. As a result, Grand Teton, George Washington Memorial Parkway, Valley Forge, Yellowstone, and Yosemite parks have more than one data collection period, as shown in the *Summary Sheets* of the *Park Traffic Report* packages for these parks.

Other exceptions to the coverage count process include the following.

- For Sequoia/Kings Canyon National Park, limited data from a new ATR station, 52011, was used as a coverage count data source for one of the road links.
- For Yellowstone stations 27042 and 2734 data were not collected due to fires in the vicinity.
- For Big Bend stations 5621 and 5622 were not collected due to washout.
- For Mammoth Cave Station 3213 data were not collected due to road closure.
- A section of the BLRI near Sims Creek Bridge (at MP 295.4 on the Parkway) was closed during the counts for the construction. U.S. Hwy 221 was used for detour. A counter was placed on the ramp that led to the detour.

- No coverage counts were collected in Rock Creek Park. Government provided data were used for AADT estimation for the Rock Creek Park. The AADT estimates for the road sections covered by these stations were based on the average traffic growth estimated for each park applied to the last available historical AADT information.

Short duration traffic counts only measure the traffic conditions when the counts are taken. To use these data to estimate "average" conditions and to develop traffic volume statistics, adjustments were made to account for the variability in the traffic flow for the year. To determine an approximate AADT and SADT for the roadway, each coverage count was factored using an annual average daily traffic factor and a seasonal average daily factor from the assigned referenced permanent ATR station. Details on the coverage count data processing and analysis are provided in the *Data Analysis* section of this report.

1.3.3 Vehicle Occupancy and Classification Data

While the data collection crews were at each park, vehicle occupancy and vehicle classification data were collected at selected locations for at least 8 consecutive hours. Locations for the vehicle occupancy and vehicle classification studies were selected to capture typical traffic composition on the park's roads. Data collectors used an electronic count board to enter the classification and/or occupancy for each location. In addition to the manual count, a digital video was taken of traffic and used to verify the manually collected data. Vehicle classification data were collected for the categories described in Table 1. Vehicle Occupancy data were collected for the categories described in Table 2. Vehicle classification and occupancy data were used to create the *Traffic Compositions Summary* pages for the individual park packages presented in the Section 2.

Table 1. NPS Vehicle Classification Categories.

NPS No.	Vehicle Type	FHWA Vehicle Class	Notes
1	Motorcycle	Class 1	Any motorized cycles
2	Passenger Vehicles	Class 2	Including SUV and non-commercial pick-up trucks
3	Recreational Vehicles (RVs)	N/A	Single units, all sizes
4	Vehicles pulling trailers or RVs	N/A	RV pulling a trailer, or vehicle pulling RV trailer
5	Transit Buses	Class 4	City busses and shuttle busses
6	Tour Buses	Class 4	Private tour operated
7	Light-duty Trucks	Classes 3 and 5	Commercial
8	Heavy-duty Trucks	Classes 6 - 13	Combined

Table 2. NPS Vehicle Occupancy Categories.

NPS No.	Vehicle Occupancy
1	Single Occupant
2	2 Occupants
3	3-6 Car Load
4	More than six(non-Bus vehicle load)
5	Empty Passenger Bus
6	Few Passenger Bus
7	Semi-Loaded Passenger Bus
8	Fully Loaded Passenger Bus

1.4 Quality Control/Quality Assurance Procedures

Before conducting traffic data studies, a Quality Assurance (QA) Plan was developed. The purpose of the QA Plan was to ensure the Government that the data collection and analysis performed under this study adequately conforms to the *FHWA Traffic Monitoring Guide* [2], the *AASHTO Guidelines for Traffic Data Programs* [1] and other applicable standards. In accordance with the principle of "Truth-in-Data" principle, the established standards and safeguards were applied to every aspect of data collection and analysis including personnel, vehicles, equipment and traffic data editing methodology, as described in the following sections.

1.4.1 Personnel

The project team used qualified and experienced field technicians and data analysts with multi-year, job-related experience. The staff was trained to put safety and quality of work first and to be time and cost effective in performing their duties. The contractor stresses the safety of its workers and public safety, especially when traffic studies are being performed. Neon safety vests, proper clothing, and traffic awareness were mandatory. Each field technician carried cellular phones and/or two-way radios to assure frequent communication with the office, other field technicians, and park management to ensure efficiency and to safely and quickly resolve any issues that arise during the data collection phase. Each technician was responsible for keeping updated logs on vehicle maintenance and performance, count equipment maintenance and performance, and a site log to document the time and location of each site's setup and notes describing the work performed.

1.4.2 Vehicles

Vehicles used by the project team were marked with company logos. The vehicles were equipped with safety light bars and strobes and are designed for off-road activities. Each vehicle was maintained according to the manufacturer's requirements. It is a mandatory contractor's policy for all drivers to follow local driving and traffic regulations. Due to the need to park vehicles off the road in order to perform traffic

studies, particular attention was paid to prevent and correct leaks (fuel, oil, anti-freeze, fluids, etc.) and in the method of pulling off and onto the road to prevent scarring and rutting of the areas adjacent to the pavement.

1.4.3 Equipment

Quality control procedures/standards were developed to assure the proper operation and long-term effectiveness of the equipment. As part of this study, the project team conducted three types of data collection activities:

- 48-Hour Volume Counts
- Manual Classification and Occupancy Studies
- GPS Data Collection

For each type of study, a set of Quality Control (QC) Procedures was developed for the operators to adhere to.

48-Hour Volume Counts

A portable automatic traffic recorder (ATR) was used to perform these studies. ATRs are battery operated event-recording devices that use inputs from pneumatic road tube. To ensure these devices operate properly, continuously, and provide accurate data, the following QC procedures were established.

General Procedures:

- Coverage counting equipment must provide accurate counts within +/- 8% of the recorded manual counts
- Each technician shall verify proper operation of counting equipment stationed in place by comparing manual counts recorded over a period of one hour or until fifty counts are recorded with the counts recorded in the vehicle counter
- 48-hour counts will not commence unless the equipment passes the manual comparison test
- Counts shall be scheduled for times where data validity will not be compromised by road construction, special events (in or near the park), and significant weather conditions which would result in atypical visitation levels
- The Contractor shall notify the Government verbally and in writing when all data collection in a Park is complete. If completeness of data is not achieved and retaking is required, then the Contractor shall immediately notify the Park and Government.

Pre-study Testing (testing for equipment malfunctions):

- ATR batteries will be tested for proper charge with mandatory replacement every three months
- ATR onboard clocks will be synchronized to proper time/time zone

- ATR will undergo full onboard diagnostics
- Pneumatic tubes will be pressure tested for leaks; suspect tubes will be replaced
- Test studies will be inputted to test data acquisition, storage and retrieval

During Study Testing (as data is being collected):

- Field technicians will visit each site twice daily and will monitor vehicles and compare to equipment counts to check for continued accuracy
- Pneumatic tubes will be visually checked for movement, adherence to the road surface, and appearance
- Traffic counters will be used to monitor vehicles to ensure proper counting
- Traffic counter clocks will be checked for accuracy
- Battery voltages will be checked for proper charge

Post Study Testing (after 48-hour period has expired and prior to leaving park)

- Pneumatic tubes will be visually checked for movement, adherence to the road surface, and appearance
- Traffic counters will be used to monitor vehicles to ensure proper counting
- Traffic counter clocks will be checked for accuracy
- Battery voltages will be checked for proper charge
- Field data review: data will be downloaded and visually verified for reasonability by comparing to historical data, other study sites, and/or generic flags (multiple zero counts, data drop-off, midnight to midnight counts, etc.)

Manual Classification and Occupancy Studies

An electronic count board was used by the field technician to enter the classification and/or occupancy for each study. These boards are designed to electronically store counts from various studies with the required drop intervals. Classification bins can be customized to fit any requirement up to 15 bins. A digital video of traffic was taken during the study and used to verify the accuracy of manually collected data. To ensure accuracy of manual classification and occupancy studies, the following QC procedures were established.

General Procedures:

- Counts shall be scheduled for times where data validity will not be compromised by road construction, special events (in or near the park), and significant weather conditions which would result in atypical visitation levels.
- A digital video of traffic should be taken during the study and used to verify the accuracy of manually collected data.
- The Contractor shall notify the Government verbally and in writing when all data collection in a Park is complete. If completeness of data is not achieved and retaking is required, then the Contractor shall immediately notify the Park and Government.

Pre-study Testing (testing for equipment malfunctions):

- Count board batteries will be tested for proper charge with mandatory replacement every three months
- Count board onboard clocks will be synchronized to proper time/time zone
- Count boards will undergo full onboard diagnostics
- Test studies will be inputted to test data acquisition, storage and retrieval
- Video cameras will be tested for operability
- Field technicians will choose a location that allows a full and unobstructed view of vehicles, safe, and non-attention drawing
- Field technicians will perform study during daylight hours

During Study Testing (as data is being collected):

- Count board clocks will be checked for accuracy
- Battery voltages will be checked for proper charge
- Video cameras will be monitored to ensure proper viewing and focus

Post Study Testing (after 48-hour period has expired and prior to leaving park)

- Count board clocks will be checked for accuracy
- Battery voltage will be checked for proper charge
- Field data review: data will be downloaded and visually verified for accuracy by comparing video data to manual count

GPS Data Collection

The field crews kept the records of GPS equipment calibration that check the compliance with the equipment manufacturer's recommendation.

1.4.4 ATR Data QA Procedures

This section of the report contains procedures for editing traffic data that were developed and implemented in the course of the study. The procedures were developed in accordance with the principle of Truth-in-Data, as stated in the *AASHTO Guidelines for Traffic Data Programs* [1].

Pre-screened ATR data were obtained from the FOTSC in a form of electronic monthly reports containing hourly traffic volume data for each day of the month and each traffic lane. These data were subjected to a series of rigorous Quality Assurance (QA) checks based on the procedures recommended in the reference documents identified in the *FHWA Traffic Monitoring Guide* [2].

The following documents containing Traffic data QA procedures and recommendations were considered in this study:

- *AASHTO Guidelines for Traffic Data Programs* [1]
- Minnesota pooled fund study to examine automated data collection procedures [5]
- QA procedures implemented in the FHWA LTPP program [6]
- QA procedures utilized in *1994 NPS Traffic Report* [4]

The *AASHTO Guidelines for Traffic Data Programs* [1] was used as our main source for the development of the QA procedures. Additionally, the documentation developed by the Minnesota pooled fund study [5], traffic data QA procedures implemented in the FHWA LTPP program [6] and the QA procedure from the *1994 NPS Traffic report* [4] were utilized.

Accounting for the unique nature of traffic flow within the national parks, the following data QA checks were developed and implemented in this study:

Check 1: *Identification Check* – Check if month, date, station, lane, and direction are properly identified and correct. If any anomalies are found, a request was sent to FOTSC to verify the data. The data were not processed further until identification information was verified and corrected.

Check 2: *Data Validity* – If the recorded traffic volume for any hours contains a null (empty field), a negative integer or an otherwise invalid value, then the entire day was flagged as being anomalous. All the data from that day for that roadway were excluded from summarization.

Check 3: *Continuous 24–Hour Data* – The data were checked to insure that 24 hours of continuous data were provided for each day and for each lane of the roadway. If a day of data did not have 24 hours of data in one of the lanes (located on the same roadway), all the data from that day for that roadway were excluded from summarization.

Check 4: *Time Check Edit* – If hourly volume for any day at 1:00 a.m. exceeded hourly volume at 1:00 p.m. for the same lane, the data were flagged for review and analysis to determine if there was an accident or road closure. A request was sent to the FOTSC to determine if the clock may be incorrect or equipment failure may have arisen midday. If one of these reasons was identified, all the data from that day for that roadway were excluded from summarization.

Check 5: *Continuous Zero Volume* – If a zero volume occurred on a lane for 12 continuous hours, the data were flagged for review and analysis to determine if there was a detector malfunction at the site. If no malfunction was

reported, and the pattern seems reasonable for a given site, the data were accepted for further processing. Example of an acceptable continuous zero hourly volume would be a low volume road during off-season period.

Check 6: *Same Non-Zero Volume* – If a same non-zero volume occurred on a lane for 4 continuous hours, the data were flagged for review and analysis to determine if there was a detector malfunction at the site. If no malfunction was reported, and the pattern seems reasonable for a given site, the data were accepted for further processing. Example of an acceptable same non-zero hourly volume would be a low volume road in early morning or late evening hours showing 1 vehicle per hour for 4 or more hours.

Check 7: *Volume by Direction* – At those stations where a two-way volume is collected, the data from each direction were compared to the total two-way volume. If a particular direction had more than 80% of the total traffic for the whole day on the two-way link, the data were flagged for review and analysis to determine if there has been a constraint to typical operating conditions, such as lane closure. If no constraints was reported and the ATR was found to be operational, then data were accepted or rejected from further summarization based on the operating characteristics of the site. Example of an acceptable high volume in one direction would be a road serving a winter ski area with high inbound volumes on Saturday, and high outbound volumes on Sunday.

Check 8: *Peak Hour Volume* – A typical roadway will experience a peak in both the AM and PM time periods, usually containing approximately 10 percent of the traffic on that roadway in the peak hour. The edit check was conducted to flag those days where the AM or PM peak hour contains more than 40% of the traffic on that link for the day. Flagged data were reviewed to determine if there has been a constraint to typical operating conditions, such as lane closure. If no constraints was reported and the ATR was found to be operational, then data were accepted or rejected from further summarization based on the operating characteristics of the site.

Check 9: *Extreme Hourly Volume per Lane* – In this test the volume recorded for each hour of the day was compared to a fixed maximum physical value of 2500 vehicles per lane per hour. Volumes that exceed this maximum value were flagged for review and analysis to check for problems with the traffic recording equipment.

Check 10: *Daily Traffic Volumes* – The traffic volumes at each station were aggregated to daily values for each day of the week. A statistical analysis was performed on the data by day of the week. If a particular station has a difference in daily traffic volume greater than three standard deviations from the annual mean

for that particular day of the week, the data for this day were flagged for review and analysis to determine if the data are valid for the site. The three standard deviations criterion was selected based on the expected high variation in traffic volume on low-volume park roadways and is consistent with the QA procedure implemented in the 1994 report.

Check 11: *Temporal Consistency Check* – The aggregated daily ATR traffic volumes for each day of the week for the month of coverage counts were compared to the Monthly Average Day-of-Week Traffic (MADWT) volumes for each day-of-week for the same month of the previous year. If aggregated daily traffic volumes differ by more than 2 standard deviations from the previous year's MADWT volumes for that particular day-of-week for that month, these data were flagged for review and analysis to determine if the data are valid for the site.

Data that passed QA checks were used to develop traffic summary statistics and traffic data adjustment factors from each permanent ATR station. These data are included in the traffic database presented in Appendix A.

For the parks road links referencing the ATR stations that are no longer in use or the parks road links where no 12-month periods of ATR data could be identified, the ATR adjustment factors from the 1994 NPS Traffic Report were utilized to develop representative traffic statistics. The ATR data QA procedures implemented in the 1994 NPS Traffic Report were reviewed and were found to comply with the QA guidelines outlined in the *FHWA Traffic Monitoring Guide* [2], the *AASHTO Guidelines for Traffic Data Programs* [1]. As such, no reprocessing of the 1994 data was undertaken under the current study.

1.4.5 Coverage Count Data QA Procedures

Collected raw coverage data were subjected to a series of edit checks as recommended in the *AASHTO Guidelines for Traffic Data Programs* [1] and the *FHWA Traffic Monitoring Guide* [2]. Using these guidelines and accounting for the unique nature of the coverage counts within the national parks, the following data QA checks were developed:

Check 1: *Identification Check* – Check if month, date, station, lane, and direction are properly identified and correct. The data will not be processed further until identification information is verified and corrected.

Check 2: *Minimum Count Duration* – Check if data are reported for a total of 48 hours. If less than 48-hours are reported, check to insure that at least 32 hours of continuous data are available. If less than 32 hours of continuous data are available, all the data from that 48-hour coverage period will be rejected.

Check 3: *Data Validity* – If the recorded traffic volume for any hours contains a null, a negative integer or an otherwise invalid value, then these hours will be excluded from the summarization.

Check 4: *Time Check Edit* – If the hourly volume for any day at 1:00 a.m. exceeds the hourly volume at 1:00 p.m. for the same lane, a check of equipment will be conducted to determine if the clock may be incorrect or equipment failure may have arisen midday.

Check 5: *Continuous Zero Volume* – If a zero volume occurred on a lane for 12 continuous hours, a check of equipment will be conducted to determine if there was a detector malfunction. If no malfunction is reported, and the pattern seems reasonable for a given site based on the pattern observed at nearby stations, the data will be accepted for further processing.

Check 6: *Same Non-Zero Volume* – If the same non-zero volume occurred on a lane for 4 continuous hours, a check of equipment will be conducted to determine if there was a detector malfunction. If no malfunction is reported, and the pattern seems reasonable for a given site based on the pattern observed at nearby stations, the data will be accepted for further processing.

Check 7: *Volume by Direction* – At the stations where a two-way volume is collected, the data from each direction will be compared to the total two-way volume. If a particular direction has more than 80% of the total traffic for the whole day on the two-way link, the data will be reviewed and a decision will be made whether to accept or to reject data from further summarization based on the operating characteristics of the site. Example of acceptable high volume in one direction would be a road serving a winter ski area with high inbound volumes on Saturday, and high outbound volumes on Sunday.

Check 8: *Peak Hour Volume* – The edit check will flag those days where the AM or PM peak hour contains more than 40% of the traffic on that link for the day. These data will be reviewed and a decision will be made whether to accept or to reject data from further summarization based on the operating characteristics of the site.

Check 9: *Extreme Hourly Volume per Lane* – In this test the volume recorded for each hour of the day will be compared to a fixed maximum physical value of 2500 vehicles per lane per hour. Volumes that exceed this maximum value would be flagged and a check of equipment will be conducted to determine if there was a detector malfunction.

Check 10: *Spatial Consistency Check* – A spatial check will be conducted for the data anomalies identified in QA checks 4 through 9. Anomalous traffic counts will be compared with the counts taken from the nearby stations located on the same road, during the same time interval, as the questionable count.

Check 11: *Minimum Amount of Valid Data* – Check if minimum of 32 consecutive hours of valid edited data are available after all previous QA edits. If less than 32 hours of continuous edited data are available, all the data from that 48-hour coverage period will be rejected.

Check 12: *Maximum Error Intervals* – Check if maximum error interval exceeds 6 consecutive hours. If more than 6 consecutive hours of data contain errors, all the data from that 48-hour coverage period will be rejected.

In addition, traffic statistics computed using coverage count data were compared with traffic statistics derived based on the historical coverage counts conducted in 1988, 1991 and 1994 to check for temporal trends.

1.5 Data Analysis

The objective of the data analysis task was to develop traffic statistics and representative traffic values for the park traffic links covered under the NPS Traffic Monitoring Program. Traffic statistics and representative traffic values were developed utilizing the available continuous count data, short-duration coverage counts, and when necessary, historical data to check and supplement current data, as described in the following sections.

1.5.1 ATR Data Summarization

ATR Data Analysis Period

ATR data were used to develop the seasonal traffic adjustment factors and to compute the traffic summary statistics. The adjustment factors are needed to expand 48-hour coverage counts to annual traffic estimates. ATR data collected over a 12-month period were used for the data analysis and summarization. Whenever available, the ATR data from a continuous 12-month period ending with the coverage count month were utilized. The 12-month ATR analysis period was defined for each park based on the coverage count schedule. Typically, the ATR analysis period for a given park would start with the month following the coverage count month for the previous year and end with the month when actual coverage counts are taken. For example, if coverage counts are scheduled for the month of June 2004, then the 12-month analysis period would start in July 2003 and end in June 2004. The adjustment factors,

developed using this approach, accurately depict traffic trends for the 12-month period ending by the month of coverage counts.

In some circumstances it was not be possible to obtain 12-months of ATR data, ending with a coverage count month, mostly due to intermittent problems with the ATR equipment. In these cases, the closest consecutive 12-month period of available ATR data was used, going back to 1994. If only 10 or 11 consecutive months of ATR data was identified in the period, data for one or two months from a previous year or a following year was substituted to obtain a 12 month period of ATR data.

For the parks road links referencing the ATR stations that are no longer in use or the parks road links where no 12-month periods of ATR data could be identified, season adjustments of 48-hour coverage counts were made using the following two approaches listed in the order of preference:

- Statistical technique called cluster analysis was used to identify what ATR stations within the park have similar seasonal traffic trends. Recent continuous data (12-months) from the ATR stations identified as "similar" (based on the cluster analysis results) were used for seasonal adjustment factoring in place of the data from ATR stations that are no longer in service.

- The ATR adjustment factors from the 1994 NPS Traffic Report were used to expand the 48-hour coverage counts to obtain the annual traffic estimates. Prior to using the historical adjustment factors, the available historical data were analyzed to see if the seasonal traffic pattern is stable or changes from year to year. If significant changes in the seasonal pattern were detected over the years, the 48-hour coverage counts were adjusted to annual traffic estimates using monthly averages of all available historical adjustment factors for the reference ATR site.

ATR Summary Statistics

After the QA checks were completed, ATR daily traffic volume summaries were computed from the hourly data and were used to develop the following traffic statistics for each road link with ATR detectors:

- Monthly Average Days of the Week Traffic (MADWT)
- Monthly Average Weekday Traffic (MAWDT)
- Monthly Average Weekend Traffic (MAWET)
- Monthly Average Daily Traffic (MADT)
- Annual Average Weekday Traffic (AAWDT)
- Annual Average Weekend Traffic (AAWET)
- Annual Average Daily Traffic (AADT)
- Seasonal Average Daily Traffic (SADT)

- Annual Average Daily Traffic Factor (AADTF)
- Seasonal Average Daily Traffic Factor (SADTF)
- Percentile Directional Split (PDS)
- Design Hourly Volume (DHV)

The following sections describe the computational procedures used to compute the ATR summary statistics and the traffic adjustment factors.

Compute Monthly Average Day of the Week Traffic (MADWT)

To compute this statistic, the daily traffic volumes for each of the seven days of the week are averaged for each month. For example, the daily traffic for all of the Mondays in January are added together and divided by the total number of Mondays in January to provide a MADWT for a Monday in January. These values will be used to calculate the remaining statistics for the report.

$$MADWT_{ij} = \frac{1}{n}\sum_{1}^{n} VOL_{ijn} \quad (1)$$

Where:

MADWT = Monthly average day-of-week traffic volume for day-of-week *i* and month *j*
VOL = Daily traffic volume for *k*-th occurrence of day-of-week *i* in the month *j*
i = Day of the week (Monday = 1, Tuesday = 2, Wednesday =3, Thursday = 4, Friday =5, Saturday = 6, Sunday =7)
j = Month of the year
n = the number of occurrences of day-of-week i during that month j (usually between 1 and 5, depending on the number of missing data).

Compute Monthly Average Weekday Traffic (MAWDT)

To compute this statistic, the MADWT for Monday through Friday are summed and then divided by 5.

$$MAWDT_{j} = \frac{1}{5}\sum_{i=1}^{5} MADWT_{ij} \quad (2)$$

Where:

MAWDT = Monthly average weekday traffic volume for month *j*
MADWT = Monthly average day-of-week traffic volume for day-of-week *i* and month *j*
i = Day of the week (Monday = 1, Tuesday = 2, Wednesday =3, Thursday = 4, Friday =5, Saturday = 6, Sunday =7)
j = Month of the year

Compute Monthly Average Weekend Traffic (MAWET)

To compute this statistic, the MADWT for Saturday and Sunday are summed and then divided by 2.

$$MAWET_j = \frac{1}{2}\sum_{i=6}^{7} MADWT_{ij} \quad (3)$$

Where:

MAWET = Monthly average weekend traffic volume for month *j*
MADWT = Monthly average day-of-week traffic volume for day-of-week *i* and month *j*
i = Day of the week (Monday = 1, Tuesday = 2, Wednesday =3, Thursday = 4, Friday =5, Saturday = 6, Sunday =7)
j = Month of the year

Compute Monthly Average Daily Traffic (MADT)

The AASHTO [1] formulation for calculation of MADT is used. To compute this statistic, the MADWT for Monday through Sunday are summed and then divided by 7.

$$MADT_j = \frac{1}{7}\sum_{i=1}^{7} MADWT_{ij} \quad (4)$$

Where:

MAWDT = Monthly average weekday traffic volume for month *j*
MADWT = Monthly average day-of-week traffic volume for day-of-week *i* and month *j*
i = Day of the week (Monday = 1, Tuesday = 2, Wednesday =3, Thursday = 4, Friday =5, Saturday = 6, Sunday =7)
j = Month of the year

Compute Annual Average Weekday Traffic (AAWDT)

To compute this statistic, the MAWDT's for each month are summed and then divided by 12.

$$AAWDT = \frac{1}{12}\sum_{j=1}^{12} MAWDT_j \quad (5)$$

Where:

AAWDT = Annual average weekday traffic volume
MAWDT = Monthly average weekday traffic volume for month *j*
j = Month of the year

Compute Annual Average Weekend Traffic (AAWET)

To compute this statistic, the MAWET's for each month are summed and then divided by 12.

$$AAWET = \frac{1}{12}\sum_{j=1}^{12} MAWET_j \tag{6}$$

Where:

AAWET = Annual average weekend traffic volume
MAWET = Monthly average weekend traffic volume for month j
j = Month of the year

Compute AADT from ATR Data

To compute AADT, the MADT's for all twelve months of the year are summed and then divided by 12.

$$AADT = \frac{1}{12}\sum_{j=1}^{12} MADT_j = \frac{1}{12}\sum_{j=1}^{12}\left(\frac{1}{7}\sum_{i=1}^{7}\left(\frac{1}{n}\sum_{k=1}^{n} VOL_{ijk}\right)\right) \tag{7}$$

Where:

AADT = Annual average daily traffic volume
MADT = Monthly average daily traffic volume
VOL = Daily traffic volume for *k*-th occurrence of day-of-week *i* in the month *j*
i = Day of the week (Monday = 1, Tuesday = 2, Wednesday =3, Thursday = 4, Friday =5, Saturday = 6, Sunday =7)
j = Month of the year
k = 1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth occurrence of that day of the week in a month.
n = Number of days of that day of the week during that month (usually between 1 and 5, depending on the number of missing data).

The above formula is compliant with the AASHTO formulation for AADT recommended in the *FHWA Traffic Monitoring Guide* [2] and serves to remove most biases that result from missing days of data, especially when those missing days are unequally distributed across the months or the days of the week.

Compute Seasonal Average Daily Traffic (SADT)

The season is defined as those full months that contain 80 percent of the annual traffic volume for the station. Note that a park may have more than one season;

therefore, the months used in SADT computation may not be consecutive. To compute this statistic, the MADT is used to compute monthly volume for each month. Monthly volume is ranked from the highest to the lowest. Once the months with the highest cumulative traffic volumes are determined, the MADTs for those months are averaged to develop the SADT volume. The following procedure was used to calculate the SADT statistic:

1. Compute the MADT for each month.
2. Compute monthly volumes by multiplying MADT by the number of days in a month.
3. Sum the monthly volumes for all months.
4. Normalize the monthly volumes for each month by the sum of monthly volumes for all months.
5. Find a group of months that satisfy the following two conditions:
   (1) Has a cumulative of the normalized MADTs of 80% or more.
   (2) Contains the least number of months.
6. Find an average of the MADTs for those months. This average MADT is equal to the SADT volume.

Example of the SADT computation using the MADT data for the MEVE ATR Station 2010 is shown in Table 3.

Table 3. Example of the SADT computation for the MEVE ATR Station 2010.

Month	MADT	DAYS	Monthly Volume	Percent of year	Ranking by the highest MADT volume	Cumulative percentile based on ranking	Part of SADT?
1	193	31	5,983	1.78%			No
2	198	28	5,544	1.65%			No
3	377	31	11,687	3.48%			No
4	741	30	22,230	6.61%			No
5	1317	31	40,827	12.15%	4	61.18%	Yes
6	2003	30	60,090	17.88%	1	17.88%	Yes
7	1893	31	58,683	17.46%	2	35.34%	Yes
8	1485	31	46,035	13.69%	3	49.03%	Yes
9	1319	30	39,570	11.77%	5	72.95%	Yes
10	944	31	29,264	8.71%	6	81.66%	Yes
11	313	30	9,390	2.79%			No
12	221	31	6,851	2.04%			No

Total Annual Volume: 33,6154
SADT: 1,494

Compute Annual Average Daily Traffic Adjustment Factors (AADTF)

The annual average daily traffic adjustment factors computed for each ATR station were used to estimate the AADT based on the coverage counts. The AADTF provides the day-of-week and monthly adjustment of coverage traffic volumes with respect to the AADT. Based on the weekday, weekend, or any-day coverage count schedule, the annual average daily traffic volume adjustment factors will be computed for each referenced ATR station and for each month using one of the following options:

- The annual average daily traffic volume adjustment factor for weekday coverage counts is the ratio of annual average daily traffic (AADT) to monthly average weekday traffic (MAWDT).

- The annual average daily traffic volume adjustment factor for weekend coverage counts is the ratio of annual average daily traffic (AADT) to monthly average weekend traffic (MAWET).

- The annual average daily traffic volume adjustment factor for any-day coverage counts taken during weekdays is based on the formula for weekday coverage counts. Similarly, if any-day coverage count is taken during weekend, then formula for weekend coverage counts is utilized.

$$AADTF_j = \begin{cases} For\ weekday\ coverage\ counts: \dfrac{AADT}{MAWDT_j} \\ For\ weekend\ coverage\ counts: \dfrac{AADT}{MAWET_j} \end{cases} \quad (8)$$

Where:

$AADTF_j$ = Annual average daily traffic volume adjustment factor for month j
$AADT$ = Annual average daily traffic volume
$MAWDT_j$ = Monthly average weekday traffic volume for month j
$MAWET_j$ = Monthly average weekend traffic volume for month j
j = Month of the year

Compute Seasonal Average Daily Traffic Adjustment Factors

Seasonal Average Daily Traffic Adjustment Factors (SADTF) will be used to estimate the SADT based on the coverage counts. The SADTF provides the day-of-week and monthly adjustment of coverage traffic volumes with respect to the SADT volume. Based on the weekday, weekend, or any-day coverage count schedule, these factors will be computed for each referenced ATR station and for each month using one of the following options:

- The seasonal average daily traffic volume adjustment factor for weekday coverage counts is the ratio of the seasonal average daily traffic (SADT) to the monthly average weekday traffic (MAWDT).

- The seasonal average daily traffic volume adjustment factor for weekend coverage counts is the ratio of the seasonal average daily traffic (SADT) to the monthly average weekend traffic (MAWET).

- The seasonal average daily traffic volume adjustment factor for any-day coverage counts taken during weekdays is based on the formula for weekday coverage counts. Similarly, if any-day coverage count is taken during weekend, then formula for weekend coverage counts is utilized.

$$SADTF_j = \begin{cases} For\ weekday\ coverage\ \ counts: \dfrac{SADT}{MAWDT_j} \\ For\ weekend\ coverage\ \ counts: \dfrac{SADT}{MAWET_j} \end{cases} \quad (9)$$

Where:

$SADTF_j$ = Seasonal average daily traffic volume adjustment factor for month j
$SADT$ = Seasonal average daily traffic volume
$MAWDT_j$ = Monthly average weekday traffic volume for month j
$MAWET_j$ = Monthly average weekend traffic volume for month j
j = Month of the year

Compute Percentile Directional Split (PDS)

The guidelines outlined in the *Project Traffic Forecasting Handbook* [7], developed by Florida Department of Transportation, were utilized to develop the Percentile Directional Split (PDS) statistic. The PDS is the percentage of the total, two-way peak hour traffic traveling in the peak direction. For continuously monitored sites (ATR stations), the peak hour traffic is determined as the 30th highest hour of the design year. To compute the PDS, the following procedure was used:

1. Determine the peak hour traffic as the 30th highest traffic volume hour.
2. Determine the total, two-way peak hour traffic volume for the 30th highest traffic volume hour.
3. Determine the peak hour traffic volume in each direction for the 30th highest traffic volume hour.
4. Assign the higher of the two directional peak hour traffic volumes to the peak direction volume.

5. Compute the PDS as a ratio of the peak direction volume to the total, two-way peak hour traffic volume, expressed in the percentile format (report as integer, without % sign).

Compute Design Hourly Volume (DHV)

The DHV is defined as a 1-hour two-way traffic volume on a highway segment during the 30th highest volume hour of the design year. The DHV could also be related to the AADT by the K-factor. For the park roads, the K-factor represents an estimate of the seasonally adjusted AADT percentage (expressed as SADT) occurring during the 30th highest traffic volume hour in the design year. Based on the guidelines for the K-factor selection from A Policy on Geometric Design of Highway and Streets [8], a K-factor of 15% was applied uniformly to all the sections, except for the parkways sections located in urban areas. For the parkways located in urban areas (like GWMP), a K-factor of 9% was applied based on Highway Capacity Manual [9].

$$DHV = SADT \cdot K / 100 \tag{10}$$

Where:
DHV = Design Hour Volume
AADT = Annual average daily travel
K = K-factor

1.5.2 Coverage Count Data Summarization

Spatial and Temporal Biases Consideration

To counteract a temporal bias created by short duration counts, traffic volume adjustment factors (AADTF and SADTF) were developed based on the continuous monitoring data from the ATR stations located within each park unit. A close-by permanent ATR station located on a similar road type within a park was assigned as a reference station for each coverage count station to reduce a spatial bias. Seasonal and average daily volume adjustment factors were developed for each month for each reference station to be used as multipliers to adjust a base 24-hour traffic volume computed from 48-hour coverage count data.

The adjustment factors from a single continuous counter were assigned to all road segments within the influence of that counter site. The boundary of that influence zone was defined based on the road junctions that cause the nature of the traffic volume to change significantly. This approach is acceptable based on the *FHWA Traffic Monitoring Guide* [2] recommendations when the number of ATR sections is limited and the nature of traffic flow on nearby coverage count sites is not significantly different from that at the reference ATR site.

Coverage Count Summary Statistics

As a result of the coverage count data analysis, the following traffic statistics were developed for each roadway segment:

- Base 24-Hour Traffic Volume
- Annual Average Daily Traffic (AADT)
- Seasonal Average Daily Traffic (SADT)
- Annual Vehicle Miles of Travel (AVMT)
- Percentile Directional Split (PDS)
- Design Hourly Volume (DHV)

The following sections describe the computational procedures used to compute these summary statistics. Computational procedure for the AVMT is applicable to both the ATR and the coverage data.

Compute Base 24-Hour Traffic Volume

The 24-hour base count statistic was computed from the edited 48-hour coverage data using the following procedure outlined in article 6.4 of the *ASTM E1442-94, Standard Practice for Highway-Traffic Monitoring* [3]:

- If after the QA checks there are 48 consecutive hours of data are available, the sum of hourly estimates for each hour is divided by 2 to obtain the adjusted 24-hour volume for the base count statistic.

- If a minimum of 24 consecutive hours of data available after the QA checks, but less than 48-hours, then duplicate hours are averaged and no adjustments are done to the non-duplicate hours.

Using above guideline, a base 24-hour traffic volume statistic VOL_{ij} was obtained for each coverage station i during coverage count month j.

Compute AADT from Coverage Counts

A number of adjustments are required to convert a 24-hour base traffic volume statistic VOL_{ij} into an AADT estimate. For this purpose, the adjustment factors, developed from the ATR data, were used to reduce the effects of temporal bias. The following formula, based on the *FHWA Traffic Monitoring Guide* [2] guidelines, was used to convert a base 24-hour traffic volume computed from 48-hour counts to the AADT:

$$AADT_{hi} = VOL_{ij} \cdot AADTF_{jh} \tag{11}$$

Where:
$AADT_{hi}$ = Annual average daily travel at location i adjusted based on ATR location h

VOL_{ij} = 24-hour base traffic volume for month j at location i
$AADTF_{jh}$ = Annual average daily traffic volume adjustment factor for month j based on ATR location h (different $AADTF$ formulas are used for parks with weekend, weekday, and any-day coverage count schedules)

In some circumstances, where it was not possible to obtain coverage counts due to temporary road closure during the counting period, historical AADT values from the 1994 NPS Traffic Report were factored using average park traffic growth factor computed for the time period between the current and the last (1994) coverage count.

Compute SADT from Coverage Counts

To convert a base 24-hour traffic volume from 48-hour counts to the SADT, the following equation was used:

$$SADT_{hi} = VOL_{ij} \cdot SADTF_{jh} \tag{12}$$

Where:
$AADT_{hi}$ = Annual average daily travel at location i adjusted based on ATR location h
VOL_{ij} = 24-hour base traffic volume for month j at location i
$SADTF_{jh}$ = Seasonal average daily traffic volume adjustment factor for month j based on ATR location h (different $SADTF$ formulas are used for parks with weekend, weekday, and any-day coverage count schedules)

Compute Annual Vehicle Miles of Travel (AVMT)

Annual Vehicle Miles of Travel (AVMT) were estimated for each major roadway within each park unit covered by an ATR or a coverage count. To compute the AVMT for each road segment, the road segment AADT was multiplied by the number of days in the year and then multiplied by the length of road segment in miles. These AVMT estimates then were summed for an entire park unit to compute the park AVMT.

$$AVMT = AADT \cdot 365 \cdot L \tag{13}$$

Where:
$AVMT$ = Annual vehicle miles of travel
$AADT$ = Annual average daily traffic
L = Length of road segment

Compute Percentile Directional Split (PDS)

The PDS was computed as a percentage of the total, two-way peak hour traffic traveling in the peak direction [7]. For the short duration 48-hour coverage sites, the peak hour of the base 24-hour volume was used in the directional split computation. To compute the PDS, the following procedure was used:

1. Determine the peak hour as the hour with the highest two-way traffic during the base 24-hour period.
2. Determine the total, two-way peak hour traffic volume for the selected peak hour.
3. Determine the peak hour traffic volume in each direction for the selected peak hour.
4. Assign the higher of the two directional peak hour traffic volumes to the peak direction volume.
5. Compute the PDS as a ratio of the peak direction volume to the total, two-way peak hour traffic volume, expressed in the percentile format (report as integer, without % sign).

Compute Design Hourly Volume (DHV)

The DHV is defined as a 1-hour two-way traffic volume on a highway segment during the 30th highest volume hour of the design year. The DHV could also be related to the AADT by the K-factor. For the park roads, the K-factor represents an estimate of the seasonally adjusted AADT percentage (expressed as SADT) occurring during the 30th highest traffic volume hour in the design year. Based on guidelines for the K-factor selection from A Policy on Geometric Design of Highway and Streets [8], a K-factor of 15% was applied uniformly to all the sections, except for the parkways sections located in urban areas. For the parkways located in urban areas (like GWMP), a K-factor of 9% was applied based on Highway Capacity Manual [9].

$$DHV = SADT \cdot K / 100 \tag{14}$$

Where:
DHV = Design Hour Volume
$AADT$ = Annual average daily travel
K = K-factor

1.5.3 Vehicle Classification and Occupancy

Manually collected vehicle classification and occupancy counts were summarized by vehicle type or occupancy group and the percentile frequency distributions were computed. To obtain the percentile frequency distributions by vehicle type or occupancy, the following procedure was used:

1. Summarize the collected data by vehicle type or occupancy group.
2. Compute the total vehicle counts across all vehicle types or occupancy groups.
3. Obtain the percentile values for each vehicle type or occupancy group by dividing the total vehicle counts from each group by the total vehicle counts across all the groups and then by multiplying the result by 100.

1.6 Data Retention

This section of the report addresses the issues of traffic data storage for future use in FHWA FLH/NPS's planning and programming activities including design, operation, and maintenance of park road networks. Currently, NPS does not have a centralized table or database that contains traffic information from multiple months, years, and multiple ATR stations in a single application. This data organization makes data editing, data querying and cross comparison difficult and time consuming.

Under the existing contract, a prototype traffic database was developed for storage and querying of the NPS traffic information based on MS Access® technology. This database is populated with ATR and 48-hour coverage data and representative traffic statistics values for each logical traffic segment for the parks included in the 2004 NPS Traffic Data Report. The database is built on relational database management technology that allows efficient storage, management, and retrieval of traffic data.

Only data that passed the QC process and was retained are included in the database. To inform users about differences in traffic data availability and to specify how data sets for specific sites may differ, the traffic database includes information on time period and actual hourly traffic data used to derive traffic statistics. In addition, traffic database design provides means for linking with other agency databases, such as the Road Inventory Program (RIP) and Geographic Information System (GIS) databases. A detailed description of the tables included in the traffic database is provided in the Appendix A. The Traffic Database is provided on a CD as a part of the Appendix A.

1.7 VMT Summary by Park

Table 4 contains historical and current annual VMT summaries for the parks covered in 2004 NPS traffic data collection effort. Park VMT summaries were obtained by summing together VMT values for individual road links covered in the study and presented on the *Traffic Trends Summary* sheets of the *Park Traffic Packages* (see Section 2 of this report). For several parks, historical values changed slightly from the 1994 NPS Traffic Report based on updated mileage and traffic link information.

Table 4. Annual VMT Summaries by Park.

Park Name	Annual VMT (1000's)			
	1988	1991	1994	2004
Acadia National Park	10,523	12,212	9,788	8,329
Baltimore Washington Parkway	513,741	556,348	504,137	669,436
Big Bend National Park	9,487	13,713	12,471	8,202
Blue Ridge Parkway	176,251	133,324	159,412	143,057*
Chickamauga And Chattanooga	26,280	24,590	28,398	10,408
Colonial National Historic Park	27,877	23,785	32,853	32,958*
Delaware Water Gap National Recreation Area	35,066	35,789	42,003	34,354
Everglades National Park	11,526	16,863	12,792	9,971
Gateway National Recreation Area	5,857	9,723	9,979	8,077
George Washington Memorial Parkway	422,582	381,999	356,751	414,450
Gettysburg National Military Park	4,489	4,402	4,196	2,670
Glacier National Park	18,168	24,985	28,764	24,155
Glen Canyon National Recreation Area	7,950	7,200	9,833	5,830
Grand Canyon National Park	36,066	37,283	42,227	36,923
Grand Teton National Park	48,615	51,994	70,801	70,418
Great Smoky Mountains National Park	107,713	141,409	153,519	157,960
Gulf Islands National Seashore	738	8,372	10,550	7,717
Joshua Tree National Park	6,096	9,069	9,944	11,447
Lake Mead National Recreation Area	44,198	33,063	40,369	31,641
Mammoth Cave National Park	4,922	6,518	6,916	7,963
Mesa Verde National Park	11,670	17,244	13,350	7,743
Mount Rainer National Park	18,691	18,349	18,468	17760
Natchez Trace Parkway	163,146	166,737	232,021	186,065
Olympic National Park	27,431	27,474	23,429	15,494
Rock Creek Parkway	77,459	76,075	76,325	63,973
Saguaro National Park	4,826	5,044	6,847	9,229
Sequoia/Kings Canyon National Park	12,579	15,747	15,745	11,635
Shenandoah National Park	32,987	33,932	31,100	23,522
Suitland Parkway	45,094	48,260	39,476	74,789
Valley Forge National Military Park	19,247	19,247	19,247	25,900
Yellowstone National Park	149,012	228,038	231,986	208,149
Yosemite National Park	91,978	85,439	92,570	82,884*
Zion National Park	9,187	11,210	13,537	7,357
	2,181,454	2,285,436	2,359,803	2,430,466

* VMT for Blue Ridge Parkway is based on 2006 data; VMTs for Colonial and Yosemite National Parks are based on 2005 data.

1.8 References

1. *AASHTO Guidelines for Traffic Data Programs*, (1992), American Association of State Highway and Transportation Officials, Washington, D.C.
2. *FHWA Traffic Monitoring Guide*, (2001), Fourth Edition, Federal Highway Administration, Office of Highway Information and Management.
3. *American Society for Testing and Materials, Standard Practice for Highway-Traffic Monitoring*, (1994), Annual Book of ASTM Standards, ASTM E1442-94.
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